## **INSIDE**

# **Gasoline Retail Prices by Brand Diesel Retail Prices by Region**

**Counties With Thermal EOR Oil Fields Kern County Thermal EOR Oil Fields Kern County Thermal EOR Wells** in 2020 Thermal EOR Wells Outside of Kern

County in 2020 **CHP Locations and Capacity CHP Facility Count, Capacity,** 

**Generation, and Grid Sales Featured Topic: California Oil Fields With Thermal Enhanced Oil Recovery** 

CALIFORNIA GASOLINE RETAIL PRICES BY BRAND

## November 2021 vs. 2020 (Percentage Change)

76 46% higher **ARCO** 52% higher Chevron 44% higher **Hypermart** 53% higher Shell Unbranded Valero **November 2021 Averages** 76 \$4.72

45% higher 49% higher 48% higher **ARCO** \$4.49 Chevron \$4.87 \$4.33 Hypermart Shell \$4.81

Unbranded \$4.53 Valero \$4.66 CALIFORNIA DIESEL RETAIL PRICES BY REGION November 2021 vs. 2020

(Percentage Change)

49% higher

55% higher

\$4.90

\$4.71

\$4.72

Northern CA

Central CA

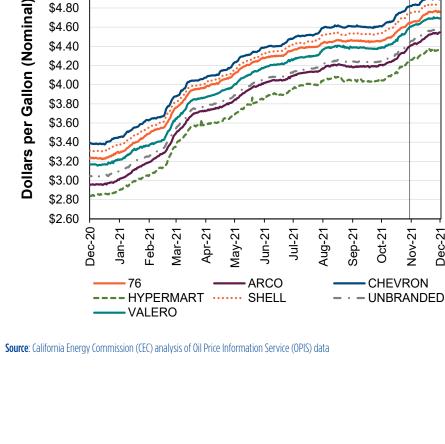
Northern CA

Central CA

Southern CA

# No news to report

\$5.20 \$5.00



\$5.20

### **Dollars per Gallon (Nominal** Southern CA 49% higher \$4.20 \$4.00 **November 2021 Averages** \$3.80

\$5.00

\$4.80

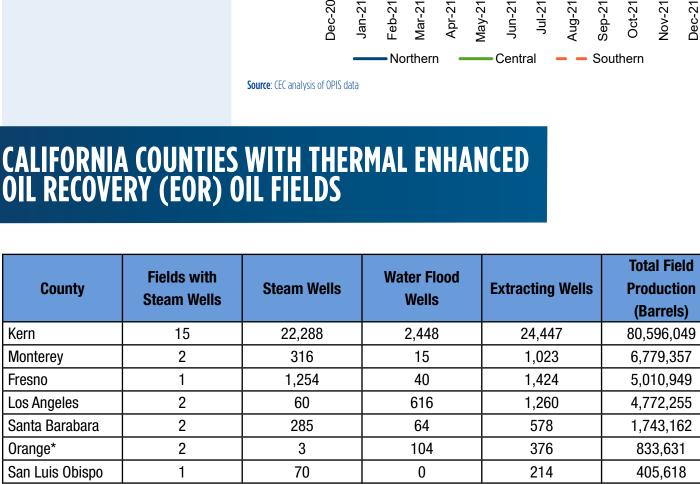
\$4.60

\$4.40

\$3.60 \$3.40

\$3.20

\$3.00 \$2.80



20

**Extracting Wells** 

6,538

1,537

94,214

**Total Field** 

**Production** 

(Barrels)

16,537,713

15,873,431

Orange

Other Operators

Berry Petroleum Company, LLC

Cogeneration Plants Total Capacity, 2020

> Petroleum Refineries Mining, Quarrying, Oil and Gas Extraction Manufacturing Excluding

### 1 11 0 Ventura Source: CEC analysis of California Geologic Energy Management Division (CalGEM) data Notes: Orange County includes off shore oil fields.

**KERN COUNTY THERMAL EOR OIL FIELDS** 

**Steam Wells** 

5,831

11,024

Belridge, South	1,725	1,264	6,047	15,831,842
Cymric	1,330	0	1,181	8,602,410
Lost Hills	560	667	3,115	8,251,732
Poso Creek	483	9	1,019	3,859,240
McKittrick	564	0	594	3,228,727
Kern Front	304	0	1,145	2,784,164
Round Mountain	180	164	622	2,281,639
Belridge, North	10	263	972	1,393,325
Mount Poso	6	70	664	1,026,513
Edison	231	9	767	550,839
Antelope Hills, North	15	0	70	191,879
Asphalto	9	0	112	134,845
Chico-Martinez	16	0	64	47,750
Source: CEC analysis of CalGem data				
THERMAL EOR WELLS AT OIL FIELDS IN KERN COUNTY IN 2020				

Water Flood

Wells

2

0

10000

8000

6000

4000

**Thermal EOR Wells** 

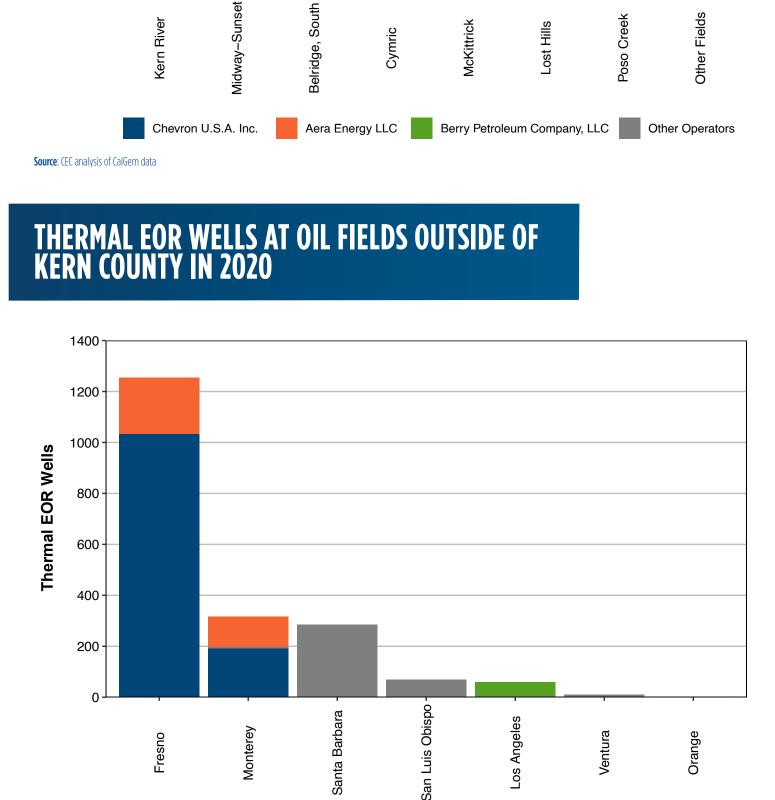
12000

**Kern Field** 

Midway-Sunset

Kern River

### 2000 0

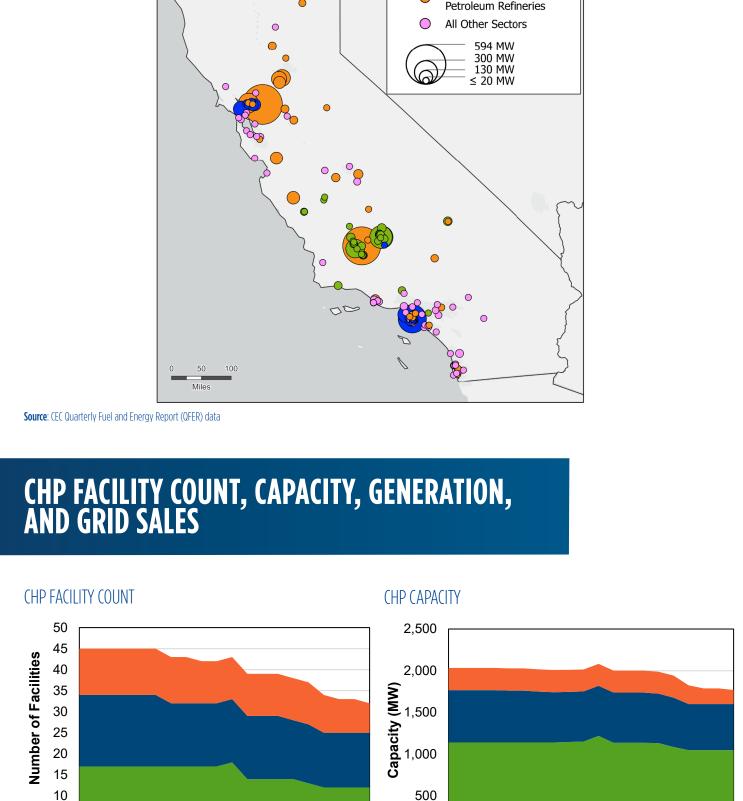


COMBINED HEAT AND POWER (CHP) LOCATIONS AND CAPACITY

Aera Energy LLC

Chevron U.S.A. Inc.

Source: CEC analysis of CalGEM data



0

CHP GRID SALES

18,000

16,000

14,000

12,000

10,000

8,000

6,000

4,000

2,000

Energy (MWh)

MAP OF OIL FIELDS IN KERN COUNTY

three fields or less, with the most

frequent number of fields being one.

There are nine different operators in

Midway-Sunset, six in McKittrick, four

As mentioned previously, thermal EOR

operations outside of Kern County only

occur in one or two fields per county.

For example, nearly all steam wells

in Fresno County are in the Coalinga

Oil Field, and nearly all steam wells

Ardo Oil Field. Operator presence in

the major oil operators, Chevron and

the most diversity with four different

OIL FIELDS IN KERN COUNTY

operators.

Aera. Operations in Santa Barbara has

More than a dozen active oil fields are

in Kern County. The Map of Oil Fields

in Kern County shows a selection

of those fields. Kern River and Kern

Front are located just to the east of

central Bakersfield. South Belridge,

Sunset run from north to south on the

western side of the county. Elk Hills,

Cymric, McKittrick, and Midway-

these large fields is dominated by

in Monterey County are in the San

in Lost Hills, and all the remaining

fields have three or fewer.

(33)

North

McKittrick

Belridge

Midway

■ Bakersfield ■ Kern less Bakersfield ■ All less Kern

■ All less Kern ■ Kern less Bakersfield ■ Bakersfield

Mount

119

166

FEATURED TOPIC **CALIFORNIA** 

**OIL FIELDS WITH** 

OIL RECOVERY

THERMAL ENHANCED

Thermal enhanced oil recovery (EOR) is an important part of California's

oil production, aiding in the recovery

of crude oil remaining in wells after extraction. Thermal EOR is a process of injecting pressurized steam into

oil reservoirs to lower the viscosity of, or thin, heavy oil to increase the flow and the amount of recoverable

crude oil. There are two steam

injection methods: steamflooding and

cyclic steaming. Steamflooding uses

heat up the oil and allow it to flow to

<u>2020 Petroleum Watch</u>). Thermal

EOR is a type of tertiary recovery, the

other types being gas injection and

chemical injection, discussed in the

November 2020 Petroleum Watch.

Thermal EOR is the most common

in California. According to a 2017

performed in the United States is

performed in California. California

oldest oil wells, with the commercial

production in the San Joaquin basin

dating back to 1887 and thermal

Now, approximately 77 percent of

comes from fields with steam wells.

California's crude oil production

EOR introduced in the 1960s.

is home to some of the nation's

96.5 percent of thermal EOR

International Energy Agency survey,

method of tertiary recovery performed

separate wells to inject steam that will

0

CHP GENERATION

18,000

16,000

14,000

12,000

10,000

8,000

6,000

4,000

2,000

Source: CEC analysis of QFER data

Energy (MWh)

■Bakersfield ■Kern less Bakersfield ■All less Kern

■ All less Kern ■ Kern less Bakersfield ■ Bakersfield

#### the extraction well. Cyclic steaming California LLC (Sentinel) is the largest is a single well operation where of the other operators by number of steam is injected into the oil well, left steam wells, has presence in four in place to soak, then pumped out fields, and is the only operator in before crude is extracted; the process San Luis Obispo County. California repeats in cycles. Steamflooding Resource Production Company is the and cyclic steaming increases the next largest. While it has presence in amount of recoverable crude oil from six fields, it predominantly operates fields with heavy crudes that have in Kern Front. All the remaining low API gravity, like those typically companies have steam wells in found in California (see February

According to the California Geologic **Energy Management Division** (CalGEM), in 2020, over 100 million barrels of crude oil production came from fields with steam wells out of California's total crude oil production of approximately 130 million barrels. THERMAL EOR IS LOCATION SPECIFIC California has extracting oil wells in 15 counties, but thermal EOR is only used in eight counties. California Counties with Thermal Enhanced Oil Recovery (TEOR) Oil Fields shows the counties in California that have steam wells, along with additional details like the number of fields that have steam wells and production quantity for 2020. Kern County is home to the most steam wells, just under 22,300 wells. The only other county with more than a thousand steam wells is Fresno, with 1,254 wells. Kern County also has the greatest amount of crude oil production from fields with steam wells, producing nearly 12 times the amount as the second ranked county, Monterey. California has 532 oil fields, 337 of those are non-producing. Of the 195 fields with production, only 26 have thermal EOR. Kern County Thermal **EOR Oil Fields** shows the individual fields in Kern County, along with the number of steam wells, waterflood

wells, extracting wells, and production. While the Kern River Oil Field has the greatest number of steam wells, it has fewer extraction wells than Midway-Sunset, the topped ranked field in Kern County by production. South Belridge has fewer steam wells but the most waterflood wells in the fields analyzed, which contributes to its rank as third highest by production. The field with the most steam wells outside of Kern County is Coalinga Oil Field in Fresno County. The field with the highest production outside Kern County is the San Ardo Oil Field, located in Monterey County. Nearly 99 percent of steam wells and oil production from steam wells within Monterey County THERMAL FOR OPERATORS Thermal EOR Wells at Oil Fields in Kern

County in 2020 shows the number

of steam wells by operator in Kern

County by oil field. Thermal EOR Wells

at Oil Fields Outside of Kern County

in 2020 shows the number of steam

Most steam wells are operated by

just a few companies, the largest

being Chevron, Aera Energy LLC, and

combine for 68 percent of production

Berry Petroleum. These companies

wells by operator in all other counties.

from fields that have steaming. In Kern County, large companies dominate the large oil fields. Chevron has the greatest number of thermal EOR wells in Kern River, Midway-Sunset, Cymric, and McKittrick. Aera is the largest operator in South Belridge, but also has wells in Midway-Sunset, Cymric, and Lost Hills. Berry Petroleum operates in Midway-Sunset, McKittrick, and Poso Creek. However, smaller operators

Combined Heat and Power (CHP) **Locations and Capacity** is a map of all the CHP facilities located in California that are one megawatt or larger. The facilities are color coded by their

North American Industry Classification

System (NAICS) code. Except for one

mining facility, which is the farthest to

the east, all other mining, quarrying,

facilities are used for oil and natural

gas extraction. Most CHP facilities

general regions: east of Bakersfield

used for thermal EOR are in two

and oil and natural gas extraction

facilities are in Bakersfield, which is home to 12 facilities and 1,048 MW of generation capacity. Six of those are in the Kern River Oil Field (857 Poso and Kern Bluff with one apiece. are located on the west side of Kern Oil Field (353 MW), three are in the remaining four are spread among South Belridge, Elk Hills, Cymric, and Lost Hills (137 MW combined). Notably, Elk Hills is the only field with thermal EOR CHP that does not

in color for other manufacturing).

Source: Wilt, Michael & Schenkel, Clifford & Wratcher, Michael & Lambert, Ilia & Torres-verdin, Carlos & Tseng, Hung-Wen. (1996). Crosshole EM for Oil Field Characterization and EOR Monitoring: Field Examples from Lost Hills, California. There are 22 "Other Operators" with seven facilities with a combined steam wells. Sentinel Peak Resources capacity of 170 MW. This brings the total number of CHP facilities used for thermal EOR in 2020 to 32 with a cumulative capacity of 1,771 MW. THERMAL EOR CHP OPERATION

CHP Facility Count, Capacity,

Generation, and Grid Sales contains

thermal EOR. Each graph is broken

located in Bakersfield, those outside

four time-series of CHP used for

out into three categories: those

Bakersfield but in Kern County,

and those outside Kern County.

While the number of facilities has

decreased by nearly a quarter over

the past decade, and most of that

has occurred in Kern County, it is

still home to the majority of thermal

EOR facilities. The decline in facility

count is greater than the decline in

generation capacity, which means

that while there are fewer facilities

now, they tend to be larger in size.

these CHP facilities is used onsite,

most of the electricity generated is

& Electric and Southern California

Edison own multiple transmission

allowing electricity from these

facilities to move to load centers

to the north and south of the state.

The percentage of electricity sold to

the grid has declined over time but

is still mostly exported. The percent

of electricity sold to the grid was

around 86 percent near the turn of

the century, down to 83 percent in

2010, and 71 percent in 2020.

lines that pass through Kern County,

exported to the grid. Both Pacific Gas

While the steam generated at

located adjacent to these fields to Capacity factor is the ratio of actual the east, is unique in that, in addition generation over potential generation to oil, it is responsible for more if the plant operated at full capacity, than half (53.5 percent) of in-state typically expressed as a percent. natural gas production, according Capacity factor is seen as the to the CalGEM 2019 Annual Report. indicator of a plant's utility or how California's demand for natural gas much it is being used. The capacity is far greater than what it produces factor for thermal EOR CHP was as in state; nearly <u>90 percent</u> of natural high as 92 percent in 2003 but has gas used in California is imported. CHP USED FOR THERMAL EOR Steam for the oil fields is traditionally produced using either boilers or combined heat and power (CHP). CHP, also known as cogeneration, is the simultaneous production of electricity and thermal energy, where the thermal energy is then used for an industrial process. In this case, the thermal energy is used for thermal EOR. (Concentrated solar powered steam CONCLUSION tubes are used as well but are newer and infrequently used.) Since boilers While not all oil fields in California use and CHP are both fueled by natural thermal EOR, those that do play an gas, the economics of steaming outsized role in oil production within are mainly a function of the price of the state. Thermal EOR is concentrated natural gas and the price of crude oil.

steadily declined since then to only 31 percent in 2020. While thermal EOR CHP facilities are exporting slightly less of their generation, they are generating significantly less in total. This is a long term downward trend, capacity factor had a bigger decline between 2018 and 2019 than between 2019 and 2020. The largest single year decline was between 2014 and 2015 (52% to 44%), which was mostly related to contract issues.

in a limited number of oil fields in the

United States, mostly found in Kern

County and its neighboring counties.

Essentially, thermal EOR CHP facilities

burn imported natural gas to help

extract petroleum locally. California

has policies in place to phase out both

and petroleum for passenger vehicles.

Newsom's **Executive Order** calling for

elimination of new internal combustion

natural gas for electricity generation

These policies include Governor

passenger vehicles by 2035, and

Senate Bill 100 requiring renewable

solar power plants built in the region. state must navigate a stable transition

renewable energy deployment, and utilizing legacy transmission assets, all while maintaining a dependable electricity supply. Visit our website for more information about California's Petroleum Market and Combined Heat and Power.

Karen Douglas, J.D. J. Andrew McAllister, Ph.D. **Patty Monahan** Commissioners **Drew Bohan** 

Executive Director

energy and zero-carbon resources to and the west side of Kern County. supply 100 percent of electric retail In 2020, Kern County was home to 25 sales to end-use customers by 2045. facilities with a cumulative capacity of With a few exceptions, most thermal 1,601 megawatts (MW). Most of those EOR CHP facilities were built between 1982 and 1995, so the newer facilities are 26 years old, and the oldest facilities are approaching 40 years. Staff anticipates that MW), four are in Kern Front (191 MW), more facilities will retire in the and the remaining facilities are in Mt. coming years as equipment reaches the end of its life expectancy. The 13 facilities outside of Bakersfield However, in the near-term, these CHP facilities provide system reliability by County. Six are in the Midway-Sunset maintaining their generation capacity and providing energy during peak McKittrick Oil Field (63 MW), and the demand hours. Transmission assets that were built to bring electricity from these CHP facilities to the rest of the state could instead be used to bring renewable generation from currently have any active steam wells. To meet its clean energy goals, the In addition to the thermal EOR CHP facilities, there is a large CHP facility away from fossil fuels. This requires (567 MW) located in Elk Hills whose managing the retirement of CHP NAICS code indicates that it is used resources in the region, supporting for natural gas processing (orange

The remaining counties (consisting of Fresno, Los Angeles, Monterey, Orange, and Santa Barbara) each have one or two facilities, totaling

**Gavin Newsom** Governor Chair Siva Gunda Vice Chair FOR MORE INFORMATION **California's Petroleum Market Weekly Fuels Watch** 

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can have a greater presence in smaller fields. For example, E&B **Natural Resources Management** Corporation is the other operator in Poso Creek and has the most steam wells in that field. "Other Fields" consists of eight additional oil fields. **David Hochschild** 

all have thermal EOR CHP.

The top eight fields in Kern County ranked by number of steam wells

in

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